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TECHNICAL REPORT

NORSAR PHASE 2

FIELD OPERATION AND MAINTENANCE 1 JUNE 1969 TO 30 JUNE 1970

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TECHNICAL REPORT

NORSAR (NORWEGIAN SEISMIC ARRAY)
PHASE 2

FIELD OPERATION AND MAINTENANCE
1 JUNE 1969 TO 30 JUNE 1970

NORWEGIAN DEFENCE
RESEARCH ESTABLISHMENT
N-2007 KJELLER - NORWAY
INTERN RAPPORT S-58

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FOREWORD

This research project is sponsored and supported by the Advanced Research Projects Agency of the Department of Defense. Technical guidance and direction for Contract No F61052-68-C-0060 has been provided by the Electronic Systems Division (AFSC). Contract support was provided by the European Office of Aerospace Research (EOAR), the R&D Contracts Division of ESD and the Air Force Logistics Command (Contract Management Center Det 16). This Field O&M report covers the period from 1 June 1969 through June 1970.

We wish to acknowledge the very considerable support and assistance provided during the course of this project by the Nuclear Test Detection Office (ARPA), the Seismic Array Program Office (ESD), the European Office of Aerospace Research (EOAR), the Seismic Array Analysis Center (SAAC) of IBM, and Teledyne, Geotech Division.

This report has been reviewed and is approved.

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CONTENTS

NORSAR PHASE 2 - FIELD OPERATION AND MAINTENANCE 1 JUNE 1969 TO 30 JUNE 1970

SUMMARY

This report covers O&M activity in the field during the period 1 June 1969 to 30 June 1970, and succeeds Technical Report "NORSAR Phase 2 - Operation and Maintenance, 1 Dec 68 to 31 May 69", later referred to as (1). In the following this activity will normally be termed FO&M to distinguish it from O&M of the Data Processing Center (DPC) at Kjeller.

1 INTRODUCTION

Since on site data recording did not take place during the period, the FO&M organisation concentrated its efforts on performing other work assigned.

1.1 Field operation and maintenance (FO&M) tasks

A simple, general definition cannot easily be given, as the FO&M group's participation in the various subjects spreads over a very wide range. Instead, a discussion of each task will give a better understanding of its nature and extent.

2 INSTALLATION AND CHECK-OUT

This task (see (1) chapter 4 and (2)), also comprising re-check of earlier installations, continued throughout most of this reporting period.

2.1 Check-out of LP/SP installations (C-ring)

This rather time-consuming work (see (2) chapter 7) required that 2 - 3 men were available until completion in Feb/Mar 70. Procedures and calibration data for this program are reported in NORSAR Phase II, Document IV, Parts 1 and 2 (see (2) section 1.2 for information about this document series).

2.2 Re-check of B-ring installations

The main purpose was to check the data cables, RA-5 amplifiers and the signal flow from the SP sensors. This check showed that four RA-5 amplifiers had to be replaced and brought to the Maintenance Center (MC) at Kjeller for further investigation. Malfunctions appeared as signal distortion, and in one case - no signal output.

A considerable amount of 50 Hz noise was measured at subarrays 01A, 04B, 06B and 07B. Data concerning 50 Hz noise at all subarrays are included in Table 2.1.

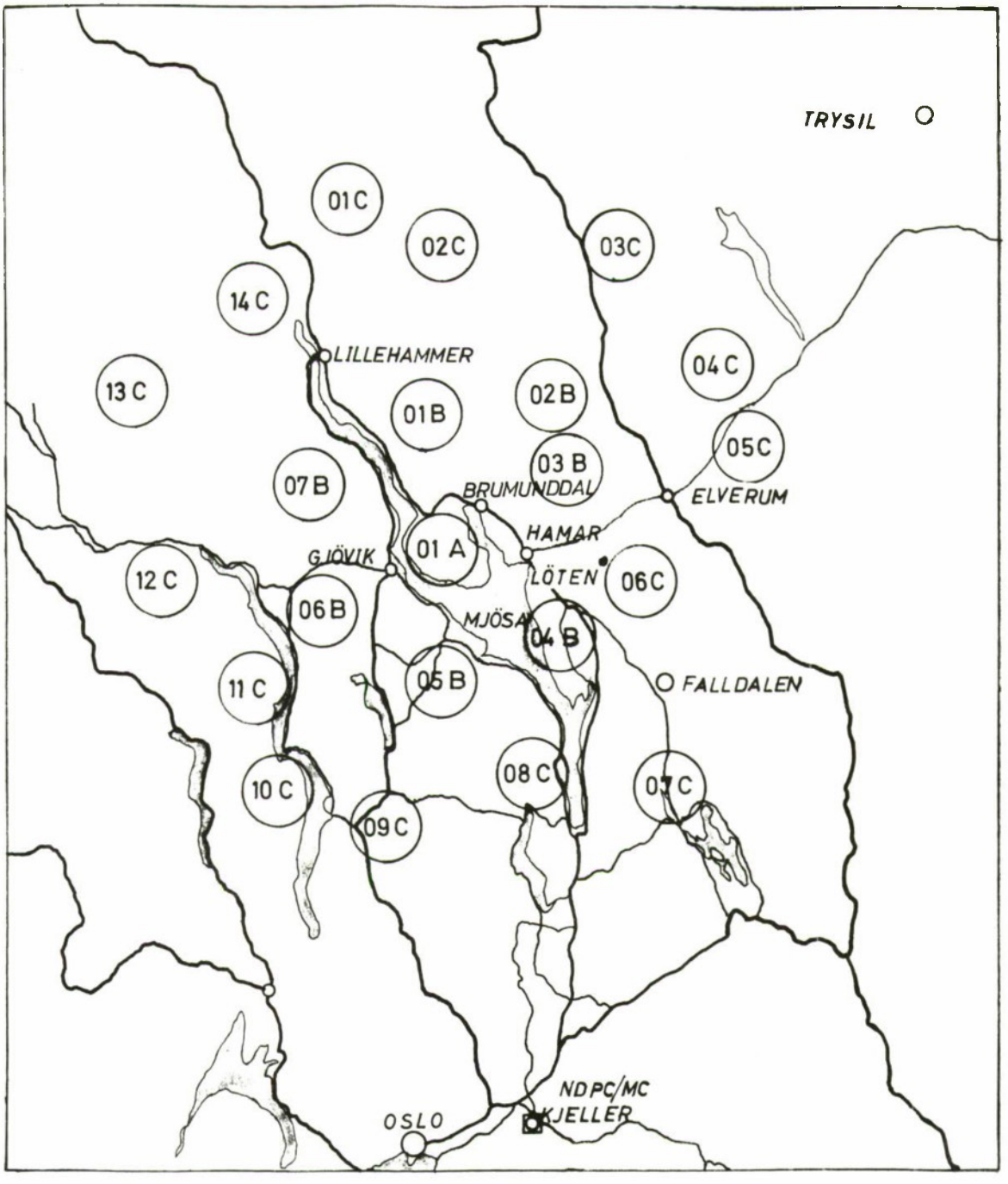


Figure 1.1 Geographical area of interest for the FO&M group

Subarray	Sensor	RA-5 (mV)	TS terminal (mV)	Subarray	Sensor	RA-5 (mV)	TS terminal (mV)
01A	00	600	550	01C	00	10	20
	01	600	600		01	0	0
	02	500	600		02	10	100
	03	500	800		03	10	0
	04	500	600		04	0	50
	05	500	400		05	0	0
	11	500	600				
01B	00	200	50	02C	00	150	100
	01	120	100		01	200	100
	02	200	50		02	200	150
	03	150	150		03	150	100
	04	200	100		04	300	150
	05	150	100		05	150	250
	10	200	800				
02B	00	180	150	03C	00	200	150
	01	150	200		01	250	150
	02	120	150		02	150	150
	03	180	150		03	300	200
	04	150	120		04	200	150
	05	150	200		05	150	150
	11	200	220				
03B	00	30	50	04C	00	170	100
	01	20	50		01	400	150
	02	40	150		02	150	80
	03	40	100		03	160	200
	04	30	100		04	180	100
	05	30	50		05	1000	200
	12	50	150				
04B	00	600	600	05C	00	200	150
	01	400	400		01	200	300
	02	200	300		02	150	300
	03	400	300		03	350	150
	04	350	400		04	50	50
	05	400	1500		05	200	100
	10	400	200				
05B	00	400	300	06C	00	400	50
	01	450	150		01	350	50
	02	150	400		02	300	100
	03	350	300		03	350	50
	04	400	200		04	250	100
	05	400	200		05	300	100
	14	200	400				
06B	00	1800	1400	07C	00	500	300
	01	2000	300		01	850	150
	02	1500	150		02	800	150
	03	1600	100		03	900	600
	04	2300	200		04	1200	250
	05	3200	300		05	650	200
	13	2000	100				
07B	00	600	400	08C	00	900	400
	01	800	250		01	300	350
	02	400	400		02	350	250
	03	500	1100		03	400	300
	04	900	200		04	300	300
	05	500	150		05	400	300
	11	1000	900				

Subarray	Sensor	RA-5 (mV)	TS terminal (mV)	Subarray	Sensor	RA-5 (mV)	TS terminal (mV)
09C	00	3400	500	12C	00	500	200
	01	5500	1500		01	800	250
	02	3300	200		02	350	250
	03	3800	150		03	350	350
	04	1800	3300		04	500	350
	05	2000	600		05	400	250
10C	00	1600	300	13C	00	250	200
	01	2000	250		01	200	100
	02	2300	300		02	300	250
	03	4000	350		03	500	250
	04	2200	300		04	250	200
	05	2000	350		05	350	200
11C	00	800	350	14C	00	900	350
	01	450	260		01	1050	600
	02	200	800		02	1050	1000
	03	250	650		03	1500	350
	04	200	300		04	1000	400
	05	400	120		05	800	300

Table 2.1 50 Hz noise levels as measured at the output of the RA-5 amplifier in the WHV and the terminals of the TS rack in the CTV

Data cables were found to be in good condition at all sites except 05B, where cable faults on SP01 and 02 did not permit testing of seismometers and amplifiers. It appeared that these cables had been cut by local farmers trenching in their fields. The system had not been in operation, and these accidents had therefore passed undetected until then.

2.3 Seismic re-check

This check-out was initiated to assure full operational capability of all field installations prior to the arrival of the Short and Long Period Electronic Modules (SLEMs) (see (2) section 7.5). The following items were checked during the period 24 March - 26 May 1970 and collected data produced by the O&M group:

a) SP instruments

Power drain
Natural frequency
TS-rack connections
RA-5, amplification at 1 Hz
upper/lower 3 dB point
noise level
common mode at 50 Hz/V input
offset at ± terminals
System, response
noise level
damping
break frequency

b) LP instruments

Amplifier gain
Amplifier DC offset
Blocked mass noise level
TS-rack connections
FP/MP motors
System response

c) Extractions from above-mentioned data concerning irregularities and malfunctions are listed below:

Site 01B LP check-out not performed. Two LP amplifiers (Itacho) had insufficient output, removed for repair. No spare available. New SP seismometer and JA-box installed at WHV-02.

Site 03B Gain on EW and Vert LP amplifiers low. Replaced.

Site 05B EW, FP-motor stuck. Replaced. Cable in WHV-01 reconnected. (Previously disconnected because of cable repair.)

Site 06B SP seismometer at WHV-00 replaced. No signal output from old one.

Site 04C LP not installed (LPV prepared for XLP).

Site 05C EW amplifier low gain. Removed, but no spare available.

Site 06C NS amplifier had too low gain in CAL AMP, OK in CAL SEIS. Amplifier remains at site.

Site 08C Leads of SP CAL AMP pair (green - white) to WHV-01 interchanged in cable-splice at Feiring. (Splice performed by NTA.) Wiring corrected in WHV and revised in CTV.

Site 10C Water in CTV (see 4.1.4 for further details).

Site 11C LP not installed. (LPV prepared for XLP.)

Site 12C EW amplifier very temperature sensitive. Needed 24 hours to stabilize. EW instrument coils replaced due to short. Removed solder remnant and grain of sand from air gap.

Site 14C EW FP-motor periodically failed. Was later rechecked and replaced.

Itacho amplifier malfunctions were related to the fact that they had been left installed without having power connected. (Manufacturer's recommendation is to store amplifiers with power on.)

SP seismometers HS10-1/A variation in natural frequency from installation to time of recheck is graphically shown in Figures 2.1 and 2.2. It should be noted that the natural frequency tolerance had not been settled at the time of these two check-outs.

2.4 Plan D

Delays in production of the SLEMs (see (2) section 6.2) indicated that no seismic data could be recorded and processed at the DRC for a long period of time. In order to shorten this period, the Advanced Research Projects Agency (ARPA) evaluated various ideas for temporary recording, and finally decided to implement the so-called "Plan D". The equipment involved in this plan consisted of a power supply, a signal conditioner and an FM-modulator, these providing for the analog signal from one SP seismometer. The equipment was installed at 18 subarrays, starting in the late fall 1969. One seismometer (in most cases the center one) was selected at each subarray. Data was transmitted via FM carrier over voice grade telephone lines to the DPC. The total capacity of the system was 18 channels, tantamount to simultaneous data collection from 18 SP seismometers. The main purpose was to utilize the available array in measuring wave propagation characteristics across the array, as a function of range and azimuth, thereby determining, prior to full-scale implementation, time delays required for detection processing. Installation and calibration at the 18 selected subarrays was completed during November/December 1969. However, further check-out took place throughout the first part of 1970. The FO&M group participated in this project with one man. Detailed information concerning recording dates etc is included in Appendix 1 of this report.

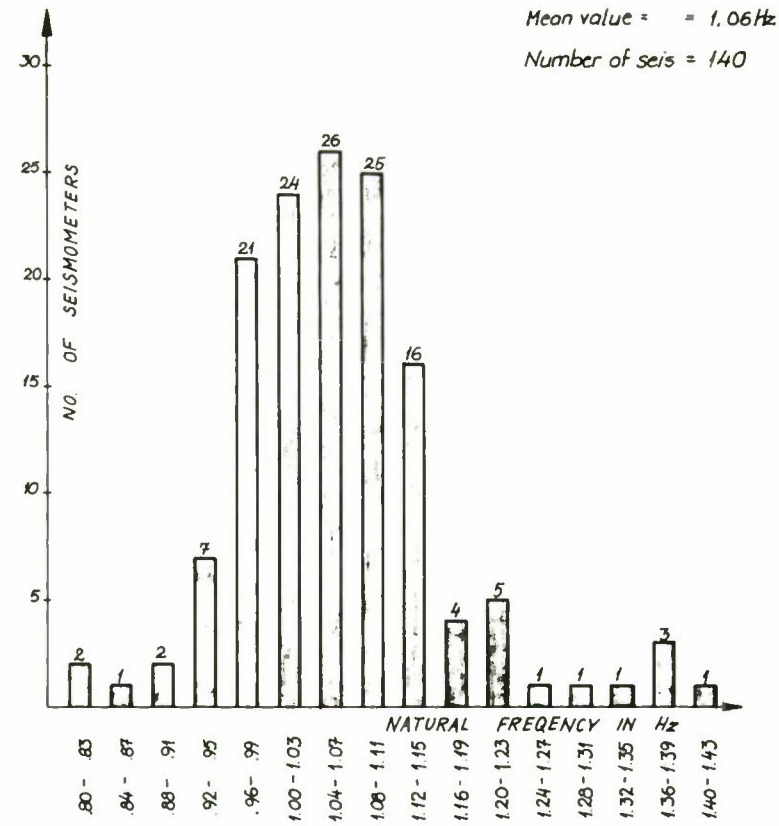


Figure 2.1 Distribution in natural frequency for SP seismometers as measured during initial installation 1968-69

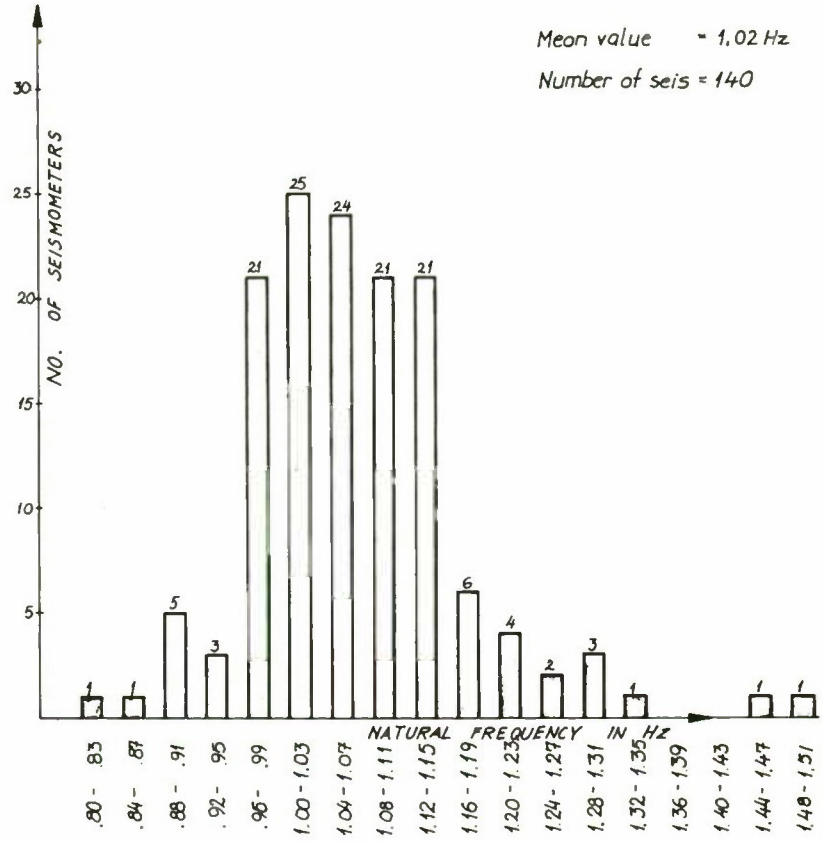


Figure 2.2 Distribution in natural frequency for SP seismometers as measured during recheck 24 March to 26 May 1970

2.5 High-gain Long Period recording (XLP)

Temporary installation at two locations of XLP equipment was discussed by ARPA (see (2) section 10.2). Recording was proposed to take place from October 1969 to May 1970. These experimental recordings were to investigate seismic data with a 50 to 80 seconds period. The LP Vaults at 04C and 11C were modified (no LP steel tanks) to meet the installation requirements. The data huts used at 07B and 06B during the on site LP recording (see (1) chapter 1) were moved to new locations at 04C and 11C, where they were to serve as support facilities.

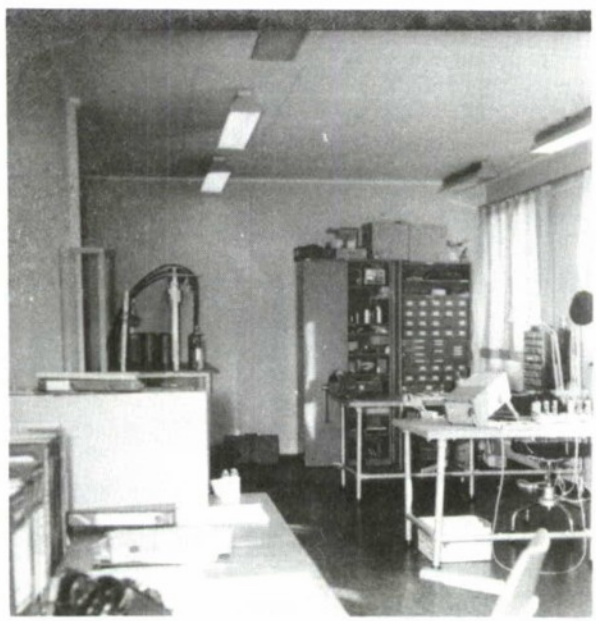
Preparations for the proposed experiment were considerably delayed and it was finally cancelled, at least insofar as NORSAR was concerned.

Reconstruction of the LPVs at these two sites had to be performed to allow normal LP installation; this delayed the installation and check-out at these vaults until Fall 1970.

3 ESTABLISHMENT OF A MAINTENANCE CENTER

Finding suitable premises for the establishment of a Maintenance Center (MC) proved to be a difficult and prolonged task (see (2) chapter 9). The Kjeller - Oslo area had earlier been decided upon as the regional location.

3.1 Temporary MC



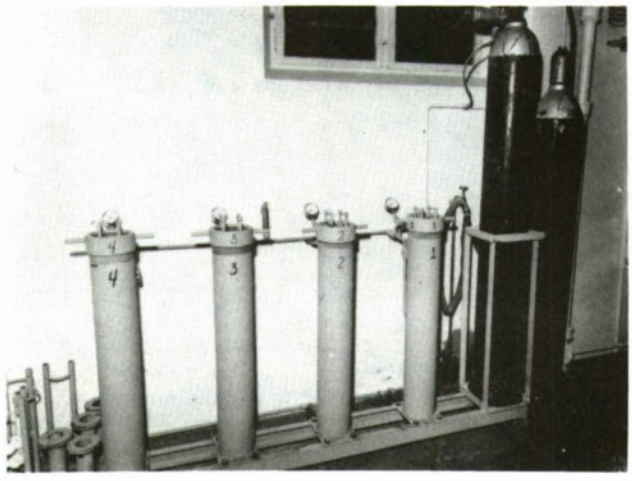
A temporary MC was established in August 1969, on the premises of the Institute for Atomic Energy (IFA), Kjeller. The rented facility comprised a workshop, approximately 50 m^2, and basement space used for pressure test-equipment.

Figure 3.1 Temporary MC

3.1.1 Noise and dust problems

The fact that electronic and mechanical repairs had to be performed in the same room had some unfortunate effects. Extreme caution had to be shown to avoid dust and metal particles from getting into seismometers. Overhaul and check-out were also hampered by locally generated noise to such an extent that complete calibration at times was made impossible.

3.1.2 Pressure test equipment



This equipment, shown in Figure 3.2, was designed and built by the FO&M staff and is based on information from Montana LASA. It is used to pressure-test the cable fittings on the SP seismometers for water leakage. A pressure of 250 psi is used.

Figure 3.2 Equipment for pressure-testing of SP seismometers

1.3 Potting table

Figure 3.3 shows the potting table where SP seismometers are finally reassembled and sealed. This device was also designed by the FO&M staff, based on information from Montana LASA.

Figure 3.3 Potting table

3.1.4 Electronic test equipment

Some equipment, most of it property of Lincoln Laboratory, MIT, was transferred from Phase 1. New equipment was purchased to establish an adequate instrumental basis for both MC and field use. A complete list of the available electronic test equipment is given in Table 3.1.

EQUIPMENT	TYPE No
Maintenance Center	
Oscilloscope, Tektronix	555
Power Supply (For Tex 555)	
Plug in unit, Time base (For Tex 555)	21ATB
Plug in unit, Time base (For Tex 555)	22ATB
Plug in unit (For Tex 555)	1A1
Plug in unit (For Tex 555)	1A2
Plug in unit (For Tex 555)	1A2
Plug in unit (For Tex 555)	1A7
Plug in unit (For Tex 555)	W
Scope Mobile (Cart For Tex 555)	202A
Oscilloscope, Tektronix	422
Battery Pack (For Tex 422)	
Oscilloscope, HP	181A
Plug in Amplifier (For HP 181A)	1801A
Plug in time B (For HP 181A)	1820A
Frequency Generator, HP	203A
Frequency Counter, HP	5233L
Digital Voltmeter, HP	3440
Plug in, Multifunction (For 3440)	3444
AC Transistor Voltmeter, HP	403A
AC Transistor Voltmeter, HP	403A
Microvolt-Microammeter, HP	425A
DC Nullvoltmeter, HP	419A
P-p Voltmeter, HP	1051
Electronic Avometer, Avo	EA113
Electronic Avometer, Avo	EA113
Multimeter, Simpson	269-3
Multimeter, Simpson	269-3
Multimeter, Triplett	310C
Megger	J100/1000
Wheatstone Bridge, Yen	2755-99
Recorder, 2 channel, Sanborn	320
Recorder, AC volts, Rustrak	19/135/8
Recorder, AC volts, Rustrak	93A
Recorder, Temp/Hum, Hygrodynamics Inc	15-4050E
Probe, Temp/Hum, Hydrodynamics Inc	15-1810
Power Supply, Seem	LV40
Power Supply, Seem	LV40
Power Supply, Seem	LV40
Precision Power Source	2005
DC Precision Voltage Source	VD11N
Decade Voltage Divider	1455A
Resistance Decade Box, Danbridge	PDR5/ABCDE
Resistance Decade Box, Danbridge	PDR5/ABCDE
Field Group 1 - Brumunddal	
Oscilloscope, Tektronix	422
Battery Pack (For Tex 422)	
Function Generator, Wavetek	116
Frequency Counter, HP	5512
Digital Voltmeter, HP	3440
Plug in, Multifunction (For 3440)	3444
Multimeter, Triplett	630NA
Megger	BM6 250 V
Recorder, Dual channel, Brush	220
Power Supply, Seem	LV40

Field Group 2 - Brumunddal	
Oscilloscope, Tektronix	422
Battery Pack (For Tex 422)	
Function Generator, Wavetek	111
Digital Voltmeter, HP	3440
Plug in, Multifunction (For 3440)	3444
Multimeter, Triplett	630NA
Megger	BM6250 V
Recorder, Dual channel, Brush	220
Power Supply, Seem	LV40
Standby - Brumunddal	
LP Monitor Control Unit, Geotech	19823
Cable Finding Equipment, Fisher	TW5
Multimeter, Triplett	630NS
Resistance Decade Box	1432M

Table 3.1 Electronic test equipment

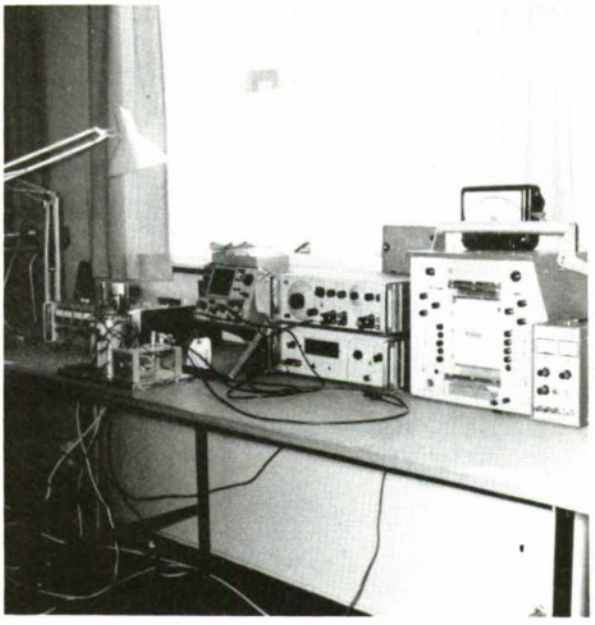


Figure 3.4 Calibration/test set-up at the temporary MC

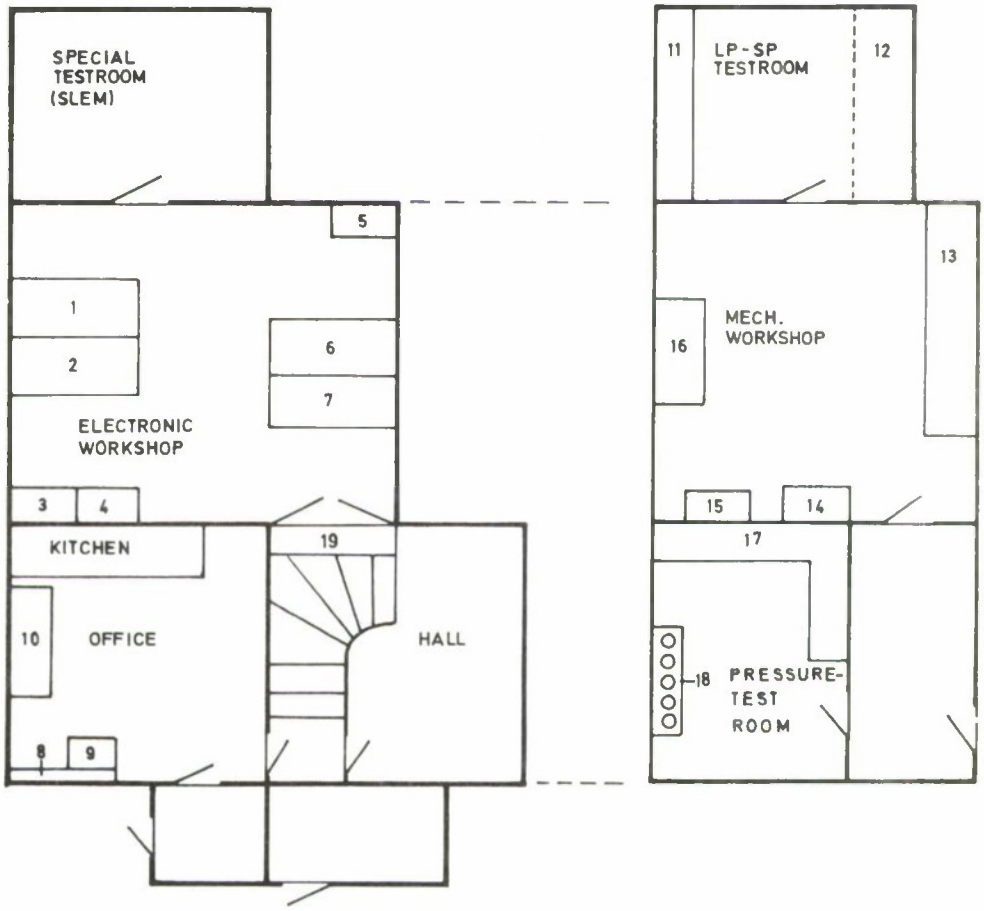
3.2 Permanent MC

Various alternatives for permanent localities for the MC were investigated. One possibility was to build a new permanent building adjacent to "Villa Sole", the quarters of the subcontractors (Noratom - Norcontrol A/S) at Kjeller. This solution could not be accepted because of the cost. Other suitable localities of the required size and within the given cost limit were not available at the time.

It was finally decided to establish the MC in an available part of "Villa Sole". The available area was ample for the time being, but it was foreseen that more space would be needed later on. If the subcontractor cannot provide any more space

Figure 3.5 "Villa Sole", the Noratom - Norcontrol A/S quarters at the Institute for Atomic Energy

within that time, an extension will have to be provided in the form of a semipermanent building adjacent to "Villa Sole". One obvious advantage with the arrangement was that Noratom - Norcontrol A/S were already established there with part of their staff and could render switchboard and secretarial service to the MC personnel. Some building reconstruction had to be done before the facility could be taken into use in February/March 1970. Figure 3.5 shows "Villa Sole" and Figure 3.6 gives the plan of the NORSAR part of the building.



1 Work table
2 Work table
3 Spare parts cabinet
4 Spare parts cabinet
5 Spare parts cabinet
6 Work table
7 Work table
8 Shelves
9 File
10 Desk
11 SP Test table
12 Planned LP Test table
13 Work bench
14 Sink
15 Parts cabinet
16 Potting table
17 Shelves
18 Pressure Test equipment
19 Instrument cabinet

Figure 3.6 Layout of permanent MC in "Villa Sole"

3.2.1 Staff at the MC

Two technicians were permanently assigned to the MC. Extra help was to be provided by the field group when other duties permitted.

3.2.2 Records

In accordance with contract requirements, a complete historical record was established on all units having US Property Numbers (USPN). An example of a History Card is shown in Figure 3.7.

Figure 3.8 shows an example of another type of record, Site History. This is a complete list of all registered units on the site and will show dates of exchange of units. One complete Site History Record consists of three cards.

Records of supply items were also made. These records were divided into two sections, one covering non-accountable and the other accountable items.

3.2.3 Technical installations

Experiences from the temporary MC had shown that a number of test jigs were required to ease the different operations. The following test devices had to be designed and made by the FO&M group:

LP test table
LP test panel
RA-5 test panel
Itacho test panel

The listed items were under development at the end of this reporting period and will be discussed in the next O&M report.

3.2.4 Error statistics

A number of errors have shown up on the SP seismometers. Table 3.2 gives a summary of corrected malfunctions.

Parameter/Error	Number of corrected malfunctions
Natural frequency	68
Replacement of data cable	68
Short in data coil	23
Cable fault	17
Leakage, data and cal coil	1
Water in seismometer	3

Table 3.2 Summary of corrected malfunctions in SP seismometers

NORSAR — History Card

Date	Event	Location	Sign.
		05C03	
14.6.65	Sent to T.I.		
3.8.65	Removed, dead		
8.8.65	LDQ1-Q2 M-7		
9.8.65	Installed M-7		
2510.65	hi. gain reset		
25.4.68	Removed, Norway Proj.		
5/68	Batteries replaced, functional check OK, sealed with Dow. Corning compound.		
6.9.71	Babance capasitor changed. Resoldered screened jumpers. Tested mercury cells, Silicone refilled Tested functionally according to RA-5 func.test. RA-5 OK.	MC	

RA-5 S/N 73 USP No. 0499

Figure 3.7 Example of a History Card (RA-5 amplifier)

NORSAR — Site History

Location	Unit ↓ \ Replacement Date →		22/3-77
CTV	TS-rack	03	0902
"	DS-rack	03	1542
"	Looping unit	03	1521
"	Battery charger	03	
"	Batteries	03	
"	SLEM PS	03	1842
"	SLEM AU	03	1841
"	SLEM DU	03	1840
LPV	LP-box	03	0928
"	LP-box	03	0931
"	LP-box	03	0933
"	LD-sens V	V	0303
"	LP-sens	E-W	0655
"	LP-sens	N-S	0654
CTV	Ithaco	03	0705
"	Ithaco	03	1550

USP NO'S

Site: 06B

Figure 3.8 Example from a Site History Record

3.2.5 Experiences

The permanent MC premises have proved to be quite acceptable. Noise problems like those discussed in section 3.1.1 are much smaller. It is considered that upon completion of the necessary installations the MC will be very useful for future maintenance of the NORSAR installations.

3.3 Heavy materials storage at Løten

A suitable storage space for cable drums etc was required, and for this purpose some 120 m^2 of a vacated mill located at Løten, some 20 km east of Hamar, was rented in July 1969.

4 OTHER TASKS

As stated in the introduction of this report, the FO&M staff has been participating in numerous other tasks. A chronological discussion of major items follows.

4.1 Closedown, packing and cleanup of temporary Phase 1 installations

During June 1969 all recording equipment at Øyer (01C) and the LP sites (01A, 06B and 07B) was disconnected, packed and prepared for shipment to the US. After provisional storage in Oslo the equipment was shipped on 16 October 1969.

4.1.1 The Øyer subarray

The Øyer subarray (01C) was originally designed with 20 SP WHVs. Only 12 of these were ever used. The remaining eight, which were at various stages of construction from only marked to completed, were now permanently covered up with soil, and the soil surface was brought back to its original shape. Field spares such as WHV barrels, lids etc were moved to and stored at Løten.

The winter road to the CTV/LPV area (access by tracked vehicles) was marked to prevent difficulties in locating the site.

4.1.2 Closedown of Phase 1 installations at Falldalen and Trysil

The installations at these two sites were of a temporary nature, except for the LPVs, and since there was no longer any need for them, they were closed down during the period 21 - 25 July 1969.

The LP instruments and junction boxes were disconnected and brought to the MC for overhaul. Power and telephone cables were disconnected and services from the local power company and telephone office were cancelled. All surface cables were recovered, wound on cable drums and brought to the Løten storage.

At Falldalen all WHVs were covered up and landscaped like the unused WHVs at Øyer. The LPVs were padlocked.

4.1.3 Cleanup of B-ring subarrays

All sites were visited, and besides general cleanup, the doors and covers on the CTVs, LPVs and 60 m WHVs were painted, the LPV manhole lock-mechanism and threaded parts on the CTV ventilation pipes were greased, and finally padlocks were installed on all CTV and LPV doors.

4.1.4 Water leakage at subarray 10C

On arrival at site 10C for seismic recheck on 8 May 1970, a considerable amount of water (15 cm above floor level) was found in the CTV. Close investigation revealed that the water leakage was caused by insufficient draining of the CTV area, whereby overflow forced its way through CTV doors and cable entrances. The CTV was emptied, and equipment and furniture were cleaned. (Drainage has later been improved to prevent further water leakage.)

4.1.5 Acceptance inspection

During the period 10 February to 18 June 1970 all CTV/LPV installations were inspected by representatives from Norconsult A/S, the main consultants, represented by Tele-plan A/S; Siemens Norge A/S, the sub-contractor on electrical and electronic installations; and Noratom - Norcontrol A/S.

4.1.6 Access descriptions

Access descriptions covering all seismic points in the 01A and the B-ring were prepared for inclusion in NORSAR Phase 2, Document I. An example is given in Figure 4.1.

4.1.7 Temperature measurements

In Spring 1970, special temperature measurements were started at 06B 02. A description of this experiment and the results will be submitted in the next FO&M report

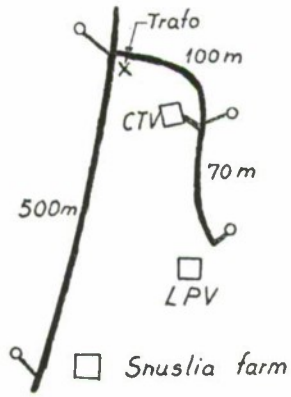
4.1.8 Rewinding of SP seismometer data coils

Because of long delivery time and high cost of replacing SP data coils, a local electronics manufacturer was contacted regarding rewinding of the SP coils. Since 16 October 1969 a number of coils have been rewound to the specifications of the seismometer deliverer. This arrangement made it possible for the MC to keep up with the demands for seismometers during the installation period. The rewound coils are of high quality, and the ocst is only a fraction of original replacements.

Aecess description for subarray 01 A - Nes

General : E 6 from OSLO to HAMAR and BRUMUNDDAL

01A - 01 (LPV): Follow E 6 north from BRUMUNDDAL approx. 1.5 km, at sign "GJØVIK" (ferje)", turn left on road 212. Pass light regulated bridge, turn right at seeond roadcrossing (KVARBERG-VIKA). Stay on road for approx. 2.8 km and turn left at HAUG farm (right side of road, approx. 250 m after blue-painted house). Follow this private road through SNUSLIA farm for approx. 3 km. and follow new aeeess road to the right. Approx. 100 m to CTV .



01A - 00: From BRUMUNDDAL follow road to KVARBERGVIKA as for 01A-01. Stay on road 212 for approx. 8.5 km passing GRAUTLIA, DOKNES and EVENRUD farms on your right. Then turn right on next farm-road,passing SKALMERUD. Continue on road approx. 700 m, take first to the left, stay on for approx. 1 km. From here, follow sketeh drawn below.

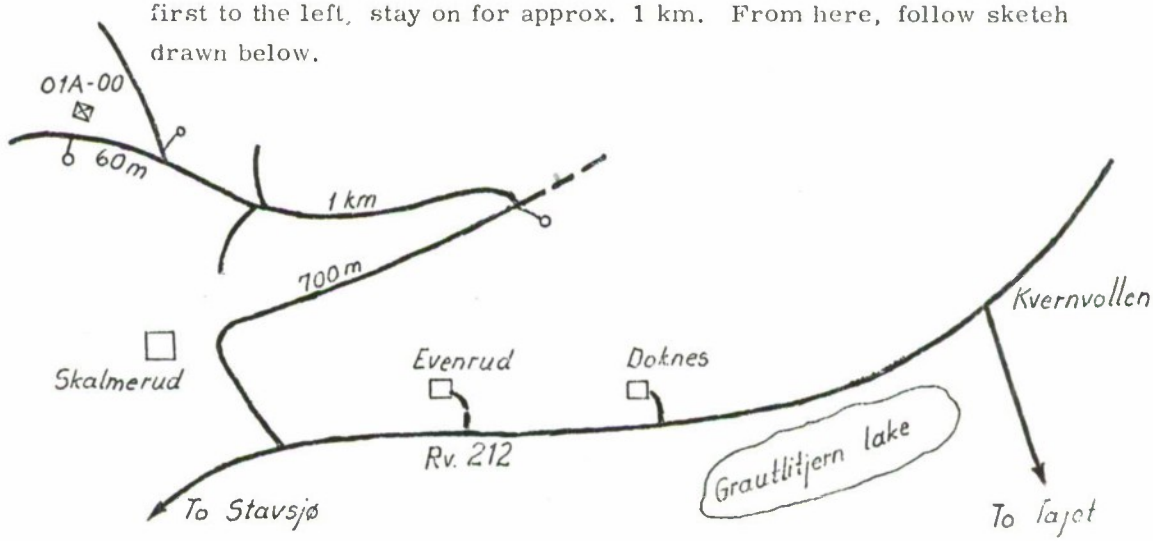


Figure 4.1 Example of access description

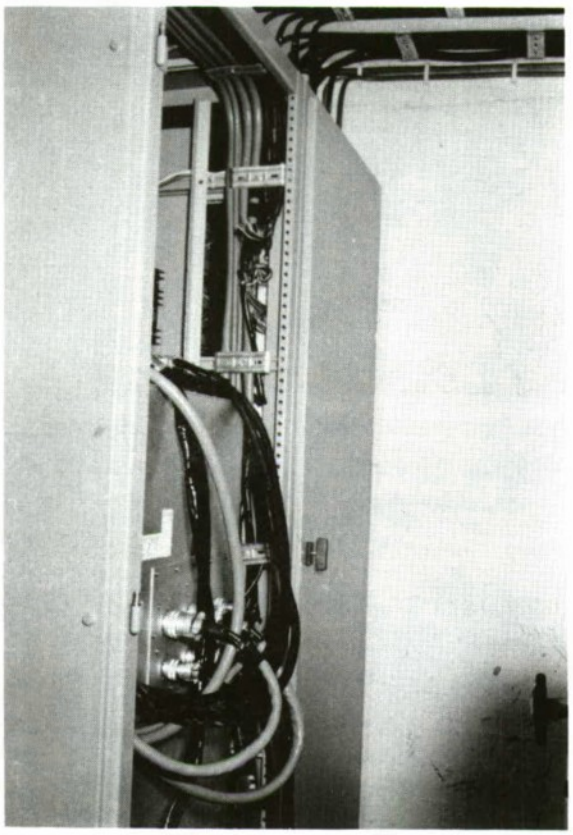
4.2 Data lines checkout

The FO&M staff has assisted Televerket, the Norwegian Telecommunication Administration (NTA), in check-out of communication lines from various sites to the DPC at Kjeller.

4.3 The Short and Long Period Modules (SLEMs)

SLEM cables arrived in March, and SLEM equipment was received throughout June 1970.

4.3.1 SLEM cables



A total of 24 sets of SLEM cables were received. Due to the fact that a great number of cables proved to be incorrectly marked, it was decided to perform a complete check-out of all cables and correct marking errors and other possible malfunctions.

Only 6 out of 24 sets were found to be without defects. A total number of 105 marking errors were detected and corrected. Appendix 2 of this report summarizes the marking errors.

The cables were later transported into the field and installed prior to SLEM arrival. Figure 4.2 shows part of the SLEM cabling as installed in the DS-rack with the SLEM units mounted.

Figure 4.2 Rear of DS-rack (SLEM cabling)

4.3.2 SLEM check-out

The FO&M staff participated in unpacking, category 2 testing and acceptance test of the SLEM units at the DPC. Two test panels for check-out of the SLEMs were designed and produced by the FO&M group (Figure 4.3).

A SLEM test-installation was performed on 29 June at 06C to check procedures and hardware.

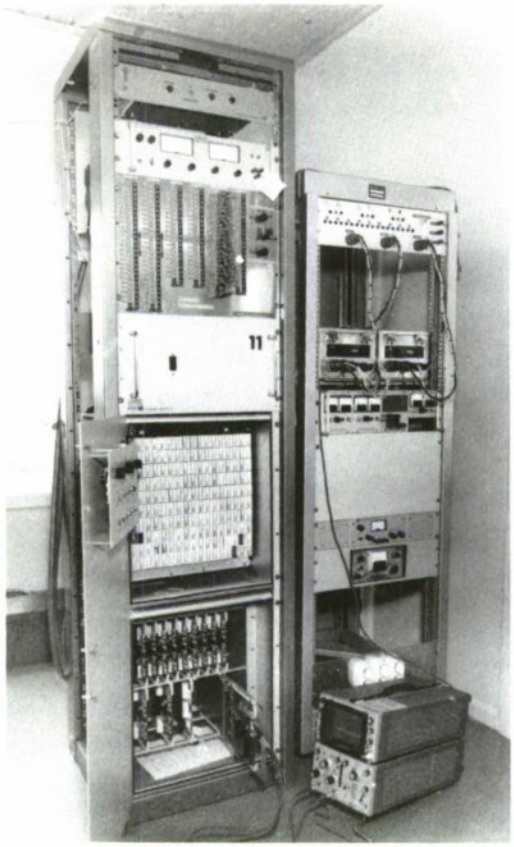


Figure 4.3 SLEM test rack (left)
The test panel is mounted above the SLEM units.

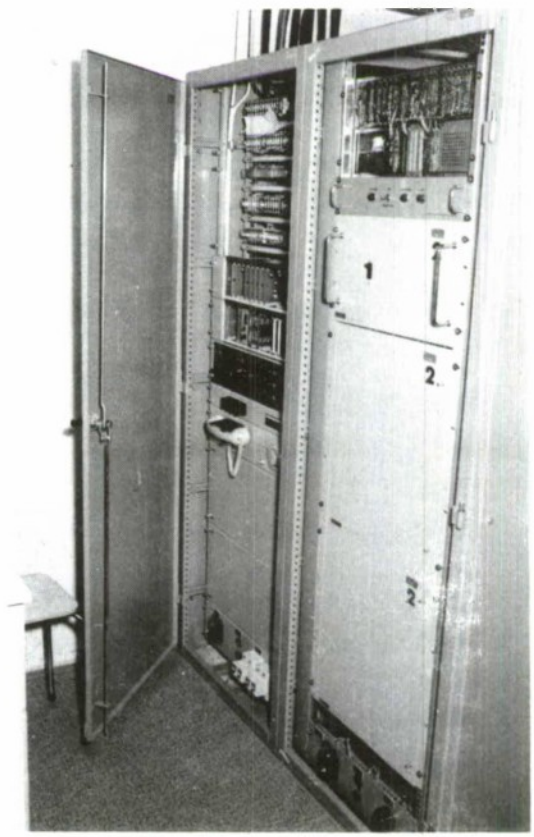


Figure 4.4 SLEM units installed in the DS-rack at site (04B)

5 STAFF AND ORGANIZATION

The tasks set forth in the Statement of Work necessitated the employment of two men at the MC overhauling seismometers and amplifiers needed for field installations. To manage the other tasks, one more technician was added to the FO&M staff in June 1969.

The staff then consisted of:

1 project leader
1 a " " assistant
2 technicians at the MC
5 " in the field maintenance group

In all, 220 000 km were covered by the FO&M staff during this reporting period.

5.1 Working schedule

A regular working schedule was almost impossible to maintain over any length of time. The field crew had to adjust its schedule to fit in with other parties involved (mainly Tele-plan, IBM and NTA).

5.2 Training

Since training on repair of seismometers and amplifiers had not been covered during Phase 1, it was proposed that two members of the staff should receive necessary training at LASA, Montana.

Later on, preparation for SLEM integration necessitated training of the complete staff on this equipment.

5.2.1 Training at LASA

The training took place during the period 26 May to 15 July 1969 and covered thorough instruction on SP seismometers type HS-10. Some time was also spent on other subjects. Table 5.1 gives the training schedule.

The FO&M staff members who participated in this training course acquired valuable knowledge, and it is also emphasized that the instructions and material provided by the Philco-Ford group has been of great help.

5.2.2 SLEM training

SLEM training was conducted by Philco-Ford representatives at "Villa Sole" during the period 28 May to 5 June 1970. This training covered theory of operation and maintenance techniques. Practical training was given as part of SLEM check-out and installation. The theoretical part of the training was excellent, but suffered somewhat from lack of access to an operational SLEM.

Week	Subject	Activity
1	Orientation	Introduction Tour of LASA Maintenance Center Field trip to sites Trip to LASA DPC
2	HS-10 Seismometer	Theory of operation Mathematical model Mechanical disassembly Parts identification
3	HS-10 Seismometer	Adjustments Check-out of seismic parameters Mechanical reassembly Cable potting Seismometer potting Pressure testing
4	LP Seismometer	Theory Shop check-out Installation preparation
5	LP Seismometer	Installation and check-out, site C3
6	RA-5 Amplifier	Shop repair and check-out Environmental testing
7	SEM	Familiarization Shop check-out Weather station
8	Procedures	Maintenance procedures Records Maintenance console operation

Table 5.1 Training schedule for the training at LASA, Montana

Course title	Hours
Versatile Common Digit Unit (VCDU)	48
SEM and LEM Analog Unit (SAU - LAU)	24
External Power Unit (EPU), SLEM installation, check-out and maintenance	8

Table 5.2 SLEM training plan

5.3 Visitor log

Visitor logs were acquired and placed at each site (CTV).

5.4 Bi-weekly report

Bi-weekly reports were prepared in conjunction with the regular NORSAR project meetings. These reports cover briefly all FO&M activities during the period 12 October 1969 to 7 March 1970.

6 SPECIAL TECHNICAL PROBLEMS

6.1 SP seismometers HS-10-1/A

The preparation of SP seismometers prior to field installation has been a major MC task. In the beginning, lack of experience together with deficient information slowed down the operation in general. Later on, problems were mainly related to unexpected changes in natural frequency and the overall condition of seismometers received from LASA.

6.1.1 Natural frequency

A considerable change in natural frequency between MC calibration in shop and check-out in the field was observed. This caused a large number to be classified as "out of tolerance", which meant they had to be replaced and brought back to the MC for recalibration.

6.1.2 Specifications

Frequency tolerance given for NORSAR SP seismometers was ± 13% (0.87 - 1.13 Hz).

6.1.3 Mechanical dislocatien

It was suspected that defaults were mainly due to mechanical dislocations inside the instruments during transport. The results of improvements in the mechanics of transport and special preventive modifications in the instrument itself (gluing suspected parts such as the main springs and the calibration spring) were disappointing. Great frequency variations still occurred. It was observed, however, that some of the seismometers returned from the field showed little or no change in frequency between the first calibration measurement at the MC and that made at the time of return to the MC.

6.1.4 Experimental frequency/temperature test

The latter observation proved to be of great importance. It indicated that the frequency changes were related to temperature variations, and an experimental frequency/temperature check was performed on a number of instruments.

6.1.5 Test results

The experiment revealed that the natural frequency of most seismometers was considerably influenced by temperature changes. The general trend was that the frequency increased with decreasing temperature. It was further noted that frequency variation is approximately linear with respect to the temperature change. The actual results of this study are shown in Figure 6.1 and Table 6.1.

Ser No	USP No	After several days in room temp ~+20 °C	Natural frequency			
			After 3 days in LPV 04B +3.5 °C	After 24 hours outside Maint C ~-20 °C	Variation from +20 °C to +3.5 °C	Variation from +20 °C to -20 °C
505	0368	1.05	1.30	1.56	+0.25	+0.51
374	0413	1.01	1.24	1.50	+0.23	+0.49
303	0396	1.09	1.18	1.30	+0.09	+0.21
489	0436	1.01	1.08	1.33	+0.07	+0.32
137	0431	1.09	1.15	0.91	+0.07	-0.18
347	0442	0.99	0.95	0.99	-0.04	—
				15 °C		
240	0398	0.93	1.27	1.35	+0.34	+0.42
207	0466	0.95	1.20	1.32	+0.25	+0.37
465	0415	0.96	1.20	1.29	+0.24	+0.33
221	0143	0.97	1.14	1.20	+0.17	+0.23
329	0433	0.94	1.10	1.22	+0.16	+0.28
579	0429	0.95	1.11	1.14	+0.16	+0.19
225	0424	0.94	1.07	1.20	+0.13	+0.26
388	0469	0.91	0.95	1.07	+0.04	+0.16
229	0461	1.01	1.01	1.18	—	+0.17

Table 6.1 Natural frequency of HS-10-1 (ARPA) SP seismometers as a function of the environmental temperature

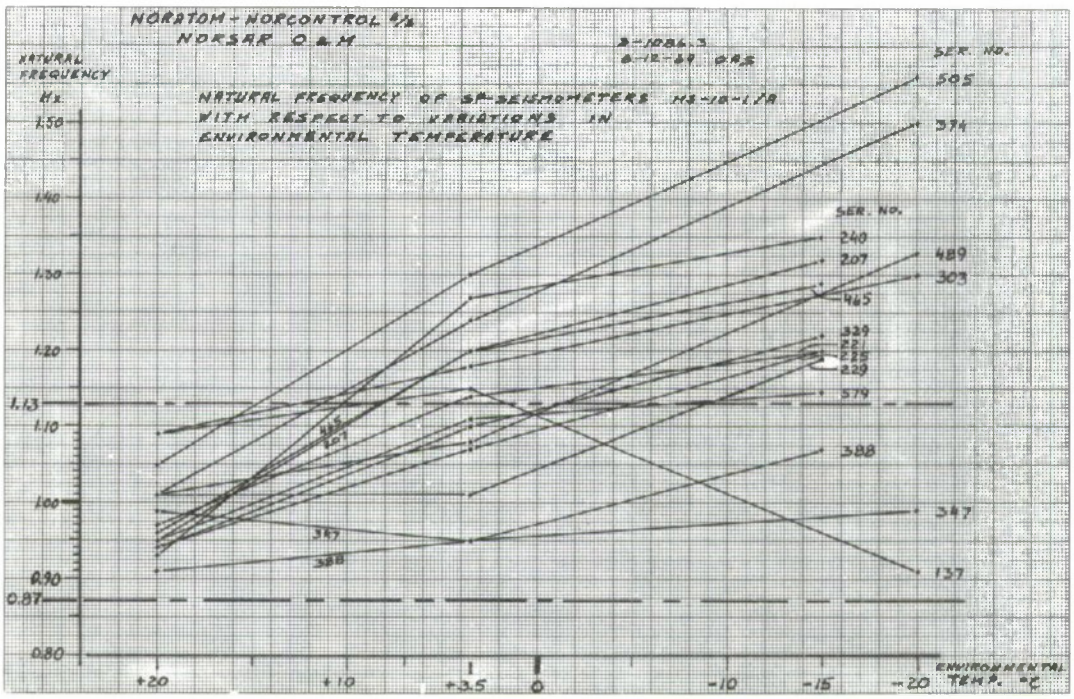


Figure 6.1 Natural frequency vs temperature for HS-10-1 (ARPA) SP seismometers
Note that the temperature scale is reversed compared to normal practice.

7 CONCLUDING REMARKS

This reporting period, from an FO&M point of view, has been demanding and interesting. A busy construction/installation period has called for full attention all the time in order to meet the proposed completion dates. Introduction of an advanced electronic system (SLEM) has been a challenge to the group as well as to the individual.

It is felt that the knowledge, skill and experience acquired by the group during this period will be of benefit for the future NORSAR operation.

References

(1) - Technical Report, NORSAR Phase 2, Operation and Maintenance, 1 Dec 68 to 31 May 69, Intern rapport S-57, Norwegian Defence Research Establishment (1971)

(2) - Final Technical Report, NORSAR Phase 2, Installations 1969 and 1970, Intern rapport S-51, Norwegian Defence Research Establishment (1971)

APPENDIX 1

INTERIM NORSAR (PLAN D) CHANNEL ASSIGNMENTS

A1.1 From 16 January 1970 - Final configuration

Sensor	Data recording dates (see Note 1)
01B00	12 November 1969
02B00	12 November 1969
05B00	17 December 1969
07B00	17 December 1969
01C00	17 December 1969
02C00	16 January 1970
03C00	17 December 1969
04C00	23 December 1969
05C00	17 December 1969
06C00	18 December 1969
07C00	19 December 1969
08C00	7 January 1970
09C00	17 December 1969
10C00	17 December 1969
11C00	19 December 1969
12C00	19 November 1969
13C00	14 November 1969
14C00	18 December 1969

Note 1: The data recording dates given reflect only the date from which data for the sensor and channel indicated are available in the final configuration. These dates do not necessarily reflect the initial data recording dates.

A1.2 From 12 November 1969 to 16 January 1970

Sensor	Data recording dates
01B00	12 November 1969
02B00	12 November 1969
03B00	12 November 1969 to 17 December 1969
05B00	17 December 1969
04B00	12 November 1969 to 17 December 1969
07B00	17 December 1969
05B00	12 November 1969 to 17 December 1969
01C00 (see Note 1 below)	17 December 1969
06B04	12 November 1969 to 17 December 1969
02C01	17 December 1969 to 16 January 1970
02C00	16 January 1970

07B00	12 November 1969 to 17 December 1969
03C00	17 December 1969
02C01	12 November 1969 to 17 December 1969
03B00	17 December 1969 to 23 December 1969
04C00	23 December 1969
03C00	18 November 1969 to 17 December 1969
05C00	17 December 1969
06C02	17 December 1969 to 18 December 1969
06C00	18 December 1969
06C02	12 November 1969 to 17 December 1969
07C00 (see Note 2)	19 December 1969
07C00	10 December 1969 to 12 December 1969
04B00	17 December 1969 to 7 January 1970
08C00	7 January 1970
09C00	17 December 1969
09C00	12 December 1969 to 17 December 1969
10C00	17 December 1969
10C00	11 December 1969 to 17 December 1969
06B04	17 December 1969 to 19 December 1969
11C00	19 December 1969
12C00	19 November 1969
13C00	14 November 1969
14C03	12 November 1969 to 18 December 1969
14C00	18 December 1969

Note 1: 01C uses different designations for the seismometers. The instrument in use is designated 0Y which is equivalent to the 00 seismometer.

Note 2: Reassignment of 07C00 to channel 11 occurred on 17 December 1969, but no data was available until 19 December 1969.

A1.3 Termination of interim NORSAR operation

The plan D equipment at the different CTVs was disconnected and removed at the same time as the SLEM equipment was installed.

The last day of operation was 7 September 1970.

APPENDIX 2

MARKING ERRORS ON SLEM CABLES

Location of cable sets	Cable no	Correct marking	Incorrectly marked
01A	W12	Cal coil 13	Cal coil 13 N
	"	Cal coil 13 N	Cal coil 13
	W41	+18 VDC	+18 VDC Ret
	"	+18 VDC Ret	+18 VDC
	"	+ 4 VDC	+40 VDC
	"	+ 4 VDC Ret	+40 VDC Ret
01B	W25	DO 13 out	DO 01 out
	"	DO 15 out	DO 04 out
02B	W38	DI W8	DI W2
	"	DI W8 Ret	DI W2 Ret
03B	W 8	Shield	Spare
	W38	DIX5	DIW5
	"	DIX5 Ret	DIW5 Ret
	W41	-12VDC	-12VDC Ret
	"	-12VDC Ret	-12VDC
	"	+12VDC	+12VDC Ret
	"	+12VDC Ret	+12VDC
04B	W10	Spare	L P chan 4
	"	Spare	L P chan 4N
05B	W25	DO21 In	DO 05 In
	"	DO21 out	DO 05 out
06B	W 2	SD	No marking
	W 8	Shield	Spare
	W10	SP chan 15	SP chan 15 N
	"	SP chan 15 N	SP chan 15
	W12	Cal coil 11	Cal coil 11N
	"	Cal coil 11N	Cal coil 11
	"	Cal coil 13	Cal coil 14
	"	Cal coil 16	Cal coil 16 N
	"	Cal coil 16 N	Cal coil 16
	W41	+40 VDC	+ 4 VDC
	"	-12 VDC Ret	-18 VDC Ret
	"	-12 VDC Ret	-18 VDC Ret
	"	-12 VDC Ret	-18 VDC Ret
	"	-12 VDC Ret	-18 VDC Ret
	"	-12 VDC Ret	-12 VDC
	"	-12 VDC Ret	-18 VDC Ret

	W41	-12 VDC Ret	-18 VDC Ret
	"	-12 VDC Ret	-18 VDC Ret
07B	W12	Spare	Cal coil 16
	"	Spare	Cal coil 16 N
01C	No errors		
02C	W10	LP chan 1N	LP chan 1
	W12	Cal coil 8	Cal coil 9
	"	Cal coil 8 N	Cal coil 9 N
	"	Cal coil 9	Cal coil 8
	"	Cal coil 9 N	Cal coil 8 N
	W25	DO 22 In	DO 22 out
	"	DO 22 out	DO 22 in
03C	No errors		
04C	W10	SP chan 1	SP chan 1 N
	"	SP chan 1 N	SP chan 1
	"	SP chan 2	SP chan 2 N
	"	SP chan 2 N	SP chan 2
	W11	A1 4	A1 4 Ret
	"	A1 4 Ret	A1 4
05C	No errors		
06C	W38	DIX6	DIW6
	"	DIX6 Ret	DIW6 Ret
07C	W10	SP chan 1	SP chan 2
	"	SP chan 1 N	SP chan 2 N
	W12	Cal coil 9	Cal coil 8
	"	Cal coil 9 N	Cal coil 8 N
	"	Cal coil 8	Cal coil 9
	"	Cal coil 8 N	Cal coil 9 N
	W41	-12 VDC Ret	+12 VDC Ret
	"	-12 VDC Ret	+12 VDC Ret
	"	+18 VDC Ret	-18 VDC Ret
	"	+18 VDC Ret	-18 VDC Ret
	"	±18 VDC Ret	-18 VDC Ret
	"	+18 VDC Ret	-18 VDC Ret
	"	-18 VDC	+ 4 VDC
	"	-18 VDC Ret	+ 4 VDC Ret
	"	-18 VDC	+ 4 VDC
	"	-18 VDC Ret	+ 4 VDC Ret
08C	W10	SP chan 17	SP chan 17 N
	"	SP chan 17 N	SP chan 17
	W12	Cal coil 16	Cal coil 16 N
	"	Cal coil 16 N	Cal coil 16

	W25	DO 25 In	DO 34 In
	"	DO 25 out	DO 34 out
08C	W41	+40 VDC	+ 4 VDC
	"	+40 VDC	+ 4 VDC
	"	+40 VDC	+ 4 VDC
	"	-12 VDC Ret	-12 VDC
	"	-12 VDC Ret	-12 VDC
	"	-12 VDC Ret	-12 VDC
	"	-12 VDC Ret	-12 VDC
09C	No errors		
10C	No errors		
11C	W25	25 IN	25 OUT
	"	25 OUT	25 IN
12C	W10	SP chan 3	LP chan 3
	"	SP chan 3 N	LP chan 3 N
13C	No errors		
14C	W41	-12 VDC	-12 VDC Ret
	"	-12 VDC Ret	-12 VDC
MC (Spare set 1)	W12	Cal coil 16	Cal coil 17
MC (Spare set 2)	W10	SP chan 15	SP chan 15 N
	"	SP chan 15 N	SP chan 15
	W12	Cal coil 22	Cal coil 22 N
	"	Cal coil 22 N	Cal coil 22
	"	Cal coil 14 N	Cal coil 14
	W25	DO 25 In	DO 34 In
	"	DO 25 out	DO 34 out
	W33	DO 64 In	DO 64 out
	"	DO 64 out	DO 64 In
	W39	Z 1	Z 1 Ret
	"	Z 1 Ret	Z 1
	W41	+40 VDC	+ 4 VDC
	"	+40 VDC Ret	+ 4 VDC Ret

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13 ABSTRACT

Project NORSAR concerns installation and operation of a large seismic array in S-E Norway.

This report covers the field operation and maintenance of the array during the period 1 June 69 to 30 June 70.

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14 KEY WORDS

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